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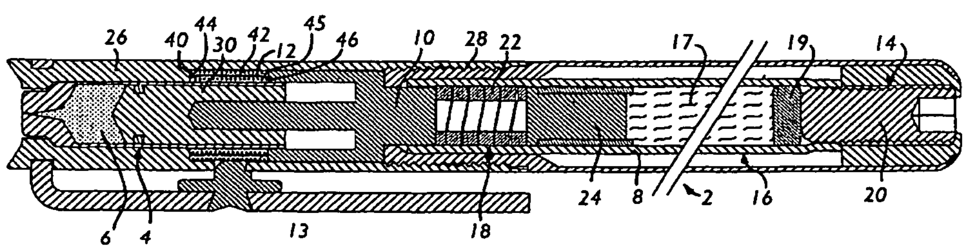

(57) Abstract: A propulsion system comprises a housing (8), a movable pressure transmiting member (10) adapted to apply a force on a device or matter to be propelled by teh propulsion system, a source of potential energy in the housing applying pressure on the pressure transmitting member, a pressure retention mechanism (12) for retaining the pressure transmitting member relative to the housing prior to actuation, and an actuation mechanism (13) for liberating the pressure transmitting member. The pressure retention mechanism comprises a retaining element mounted in compression between the pressure transmitting member and the housing, the retaining element (12) being adapted to be broken by the actuation mechanism (13) in order to release the pressure transmitting member (10).

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Propulsion System

The present invention relates to a propulsion system with a source of stored potential energy, in the form of a compressed spring or substance, that may be liberated on actuation of the system.

The potential energy liberated by the propulsion system may be used to impart kinetic energy on a fluid or any other matter in a wide variety of applications. One of these applications is to propel a liquid through a nozzle to create a liquid jet, for example for transdermal needle-free injection of a liquid pharmaceutical composition as described in international patent application WO 01/47586 A1. The propulsion system described in the aforementioned application comprises a liquid or solid substance stored in a container portion under pressures that may attain and even surpass 1000 bars. In certain embodiments, a piston used to transmit the stored energy to the liquid to be injected, closes an end of the container portion holding the compressed substance and is retained to the container portion by a rod under traction. In certain variants, the propulsion system is actuated by breaking the rod to release the piston.

Controlling the conditions under which the rod ruptures is however difficult, since on the one hand the rod should easily break when subject to a relatively small bending force, yet support very high tensile stress. Moreover, the presence of defects in the material of the rod, in particular the presence of cracks or crystalline deformations, will increase the risk of inadvertent rupture in view of the high tensile stress.

The need to reliably and securely retain the piston or other pressure retaining means while on the other hand enable easy actuation is one of the important problems faced by propulsion systems comprising a substance contained at high pressure.

An object of this invention is to provide a propulsion system, in particular comprising a source of stored potential energy in the form of a substance or spring or elastic means compressed in a container, that is safe, reliable and easy to actuate.

A further object is to provide a propulsion system that stores a high amount of potential energy per unit volume or that generates a high pressure, and that can be safely and reliably actuated.

Another object of this invention is to provide retention means for retaining a substance or spring or elastic means compressed in a propulsion system, that is easy to release in order to actuate the propulsion system.

A further object is to provide a safe, reliable, compact, and cost effective retention means for a propulsion system.

A further object is to provide retention means that can be implemented in re-usable or in single-use disposable propulsion systems.

Another object of this invention is to provide a needle-free transdermal injection device that reliably delivers a liquid to be injected, and that is safe and easy to operate.

A further object is to provide a needle-free transdermal injection device that enables the liquid to be injected to be delivered at a controlled depth, be it intradermal, sub-cutaneous, or intra-muscular.

Objects of this invention have been achieved by providing a propulsion system according to claim 1.

Disclosed herein is a propulsion system comprising a housing, a movable pressure transmitting member adapted to apply a force on a device or matter to be propelled by the propulsion system, a source of potential energy in the housing applying pressure on the pressure transmitting member, a pressure retention mechanism for retaining the pressure transmitting member relative to the housing prior to actuation, and an actuation mechanism for liberating the pressure transmitting member. The pressure retention mechanism comprises a retaining element mounted in compression between the pressure transmitting member and the housing, the retaining element adapted to be broken by the actuation mechanism in order to release the pressure transmitting member.

The retaining element may advantageously comprise a thin-walled tubular portion, for example of substantially cylindrical shape, although other profiles resistant to high axial compression forces could be provided, such profiles rupturing under an inertial shock or exertion of stresses transverse to the axial direction by trigger means. The tubular portion may advantageously have radially inwardly or outwardly curved ends, or a slight barrel shaped portion, to impart a certain bending moment in the tubular portion under compression to better control rupture thereof. The tubular portion is preferably made of a brittle material, such as a ceramic or a hardened steel. The tubular portion may advantageously be manufactured by cutting and forming slices of an extruded or rolled sheet profile, for example of martensitic steel, and subsequently hardening the sliced portions. A particularly simple and low cost pressure retaining element can thus be provided.

In re-usable propulsion systems, the retaining tube or element may be encapsulated in a packaging material, such as a soft foam, that keeps broken pieces of tube from projecting freely and leaving debris that may hinder the proper functioning of the propulsion system when re-loaded with a new retaining element. The packaging also enables the pressure retaining mechanism to be integrally mounted to a disposable device or single-use

capsule, for example containing a liquid to be propelled, for use in the propulsion system. A user thus only needs to open a housing portion, for example a front cap screwed to the housing, and replace the used capsule and/or retention mechanism after use. The pressure retaining mechanism may also be provided separately from the device or capsule and replaced separately.

The actuation mechanism may comprise a trigger head for generating a high local stress on the retaining element in a direction transverse to the axial compression direction. The actuation mechanism may comprise a spring mechanism to project the trigger head towards or against the retaining element, in a transverse or axial direction to rupture it by inertial shock.

The propulsion system may be in the form of a unit assembled to different capsules or devices, in a single-use disposable configuration or for re-use. The propulsion system may be provided with multiple energy sources to generate multi-stage propulsion forces, for example for use in needle-free transdermal injection devices to control liquid delivery depth, volume and injection time. The primary energy source may advantageously comprise a liquid or solid substance, for example a polsiloxane, compressed at high pressure, for example in the range of 400 to 2000 bars.

Further objects, advantageous aspects features of the invention will be described or will be apparent from the claims, the following description and the accompanying drawings, in which:

Figures 1a and 1b are longitudinal sections of a re-usable injection device with a propulsion system according to this invention;

Figure 1c is a longditudinal section of a cable cutting device for mounting to a propulsion system according to this invention;

Figure 1d is a longditudinal section of a piezo-electric voltage impulse device for mounting to a propulsion system according to this invention;

Figure 2a is a longitudinal section of a single-use disposable injection device with a propulsion system according to this invention;

Figures 2b to 2d are perspective views of the device of figure 2a;

Figures 3a to 3c are longitudinal sections of another embodiment of a single-use disposable injection device with a propulsion system according to this invention; and

Figure 4 is a graph illustrating different injection pressure curves over time during actuation of one-stage and two-stage injection devices according to this invention.

Referring to Figures 1a and 1b, an injection device comprises a propulsion system 2 and a disposable capsule 4 mountable thereto, for the transdermal administration of a liquid 6 contained in the capsule.

The propulsion system comprises a container 8, a pressure transmitting interface member in the form of a piston 10, a pressure retaining mechanism 12, an actuation mechnanism 13, a pressure generating mechanism 14, and a primary source of potential energy 16 for propelling the pressure transmitting member. The propulsion system may further comprise a secondary source of potential energy 18 for propelling the pressure transmitting member 10 with less force than the primary source.

In this embodiment, the primary source of potential energy is a compressible substance 17 under pressure in the container 8. The compressible substance

may comprise a polysiloxane or other substances described in international patent application WO 01/47586 A1. Polysiloxanes have the ability to store a large amount of potential energy through elastic molecular compression, for example up to 100 times more energy than a conventional metal spring occupying the same volume. The elastic property of polysiloxanes is particularly advantageous to the present invention since it allows the propulsion system to liberate a large amount of potential energy at very high pressure. This property is very useful in many applications.

In transdermal injection devices, the ability to generate very high pressure over at least an initial injection phase is important in ensuring reliable transdermal delivery of the liquid to be injected. It makes possible the production of a very fine jet, during at least an initial injection phase, that is able to pierce the skin of a patient. For example, at 1000 bars initial pressure, the liquid to be injected can be propelled through nozzle orifices having diameters around 20-60 μm with sufficient speed to pierce a patients skin, and whereby injection time is slow enough to enable the injected liquid to diffuse in the surrounding tissue thus reducing injection pain.

In conventional gas or spring loaded devices, the nozzle orifice must have a much larger diameter in view of the lower injection pressure, with the consequences that the depth of liquid delivery is more difficult to control, damage to tissue is greater, and the injection may be more painful.

In the present invention, the depth of liquid delivery can be accurately controlled by adjusting the relative contribution of the primary and secondary energy sources. The secondary source of potential energy generates a lower pressure P2 than the maximum pressure P1 generated by the primary potential energy source, as illustrated in figure 4. The compressed substance 17 liberates energy in an initial phase of high pressure injection, peaking for example at around 800 to 1000 bars, followed by liberation of pressure from the

secondary source at relatively low pressure, for example around 70 bars and less. This double-stage injection pressure is very advantageous since it enables the injection depth to be accurately controlled, for example to deliver liquids intradermally or subcutaneously. The initial high pressure enables a very fine supersonic liquid jet to be formed to pierce skin, followed by the lower pressure second stage jet to deliver the liquid at a controlled depth below the outer surface of the skin, avoiding excessive penetration that would ensue if the initial high pressure were maintained over a longer period. Furthermore, the volume of liquid to be injected can be increased with the low pressure secondary energy source, since it has a larger volumetric compression ratio than the compressible substance 17.

The multi-stage pressure propulsion system advantageously enables the desired depth of injection and the volume of injected liquid to be reliably performed by an appropriate selection and design of the primary and secondary or even further potential energy sources, and in particular by adjusting the relative stored energy of each source. Depending on the contribution of the primary energy source relative to the secondary energy source, different injection pressure characteristics over time can thus be obtained as illustrated in figure 4.

Curve B represents the pressure characteristic of a propulsion system adapted to deliver liquid intramuscularly. In this case, since the injection depth is large, the propulsion system may be provided with only the primary energy source of compressed liquid or solid substance. In the present example, initial injection pressure is 1000 bars, and decreases to 500 bars at the end of injection over an injection time Bt_1 of about 0.5 seconds. For a given volume of liquid to be injected, the pressure decrease and injection time, in other words the slope of curve B, can be varied by changing the volume of compressed substance and the nozzle orifice diameter. If a large volume of liquid is to be injected, it may however be advantageous to also have the secondary potential energy source.

Curve A represents for example the pressure characteristic of a propulsion system adapted to deliver liquid subcutaneously whereas curve C represents the pressure characteristic of a propulsion system adapted to deliver liquid intradermally. In these cases the propulsion system comprises both the primary energy source and the secondary energy source, but the stored energy of the primary energy source relative to that of the secondary energy source in a propulsion system corresponding to curve A is greater than for a propulsion system corresponding to curve C. The relative stored energy of the respective energy sources can be easily adjusted by varying the volume of compressible substance 17, a larger volume corresponding to more stored energy.

The step at injection time At_1 in curve A is achieved by providing a stop in the propulsion system container to stop, after a specified volume increase (pressure decrease), the piston or container portion separating the compressible substance from the secondary source of potential energy, such that the secondary energy source then takes over to complete injection. In a propulsion system corresponding to curve C, no stop for the primary energy source is provided, the secondary energy source taking over from the primary energy source approximately at time Ct_1 when the pressure of the compressible substance drops to the pressure exerted by the secondary energy source.

The secondary energy source may comprise: a spring, for example a metal coil spring 22, as shown in figures 1a and 1b; or a gas; or a pair of opposed permanent magnets (for example FeNd permanent magnets); or an elastic substance comprising gas-filled micro-capsules; or other elastic means. The secondary energy source is, in the embodiment of figures 1a and 1b, mounted between the pressure transmitting member 10 and a movable separating member 24 sealingly separating it from the compressible substance 17. The secondary energy source could also be mounted at the rear end of the

propulsion device, for example between the rear piston 19 and the compressible substance 17 or between the ram portion 20 and the rear piston 19.

The secondary energy source may also be directly integrated with the primary energy source, for example as a gas dissolved in the compressible substance or encapsulated in cavities or pores in the compressible substance, or as a spring or other elastic elements inserted in the compressible substance. The latter variants would simplify the design by eliminating the need for a separating piston between primary and secondary energy sources.

The pressure generating mechanism 14 is mounted to the rear end of a container and comprises a piston 19 driven by a ram portion 20 in the form of a threaded bolt engaging a complementary threaded portion of the container. As the ram portion 20 is threaded into the container, the piston 19 is displaced and compresses the compressible substance 17. The amount of turns applied to the ram portion determines the pressure of the compressible substance 17 which can thus be adjusted according to the application. The pressure generating mechanism may either be manually driven, or comprise a motor mechanism (not shown) for driving the ram portion, for example via a step down gear transmission. The motor may for example be a step motor connected to and controlled by an electronic control system (not shown).

The front end of the propulsion system is provided with a removable cap portion 26 with a threaded portion 28 for releasably mounting the capsule 4 containing the liquid to be injected. Other releasable fixing means could however be provided, such as a bayonet type connection or releasable spring latches.

A rear end of the capsule 4 is sealingly closed by a piston 30 that is driven by the propulsion system piston 10 on actuation of the device thereby propulsing

the liquid 6 through a nozzle orifice 32 provided at an applicator end 34 of the capsule. The capsule piston 30 may be provided at its front end with a cone shaped elastic member 36 in order to ensure that substantially all the liquid to be injected is propelled out of the capsule.

The capsule housing 38 is made, for example, of a plastic material, coated as appropriate for the pharmaceutical products contained therein. The nozzle portion may be provided with a metal nozzle tip embedded in the capsule housing. The nozzle orifice may have a diameter as small as 10 to 100 microns, and may of course be larger, but for most applications the orifice diameter is preferably in the range of 50 to 100 microns.

The pressure retaining mechanism 12 is mounted in compression between the movable pressure transmitting member 10 and an abutment shoulder 40 formed in the container. The pressure retaining mechanism is designed to withstand large compression stress, yet be easily fractured by a relatively small force or moment applied transversely to the direction of compression, in order to easily release the piston 10 for actuation of the propulsion system. The breakable portion of the pressure retaining mechanism is thus preferably made of a relatively brittle material, such as hardened steel or a ceramic, that is able to withstand very high compression stress but that shatters when subject to relatively low transverse forces, in particular when applied locally to generate high local stress, or to an inertial shock impulse.

The pressure retaining mechanism may advantageously comprise a tubular element 42, for example with a thin-walled cylindrical cross-section, extending between free ends 44, 45 in abutment against support shoulders 40, 46 of the propulsion system housing and the piston 10 respectively. The tubular element may be manufactured very economically by cutting slices of a whole or split tube, and during or subsequent to the cutting operation performing any finishing operations such as rounding inwardly the free ends 44, 45 and if

applicable, hardening the material. The tube may be made by extrusion, or advantageously rolled from flat stock material to provide a low cost 'C' profiled or slit tube. The inwardly rounded free ends, which provide the tubular element with a slight "barrel" shape, improve control of the rupture characteristics by generating a certain bending stress in the tube prior to actuation. The latter promotes a buckling effect that enables better control of complete rupture of the tube.

In this embodiment, the tube is encapsulated in a packaging material, such as a soft foam, that keeps broken pieces of tube from projecting freely and leaving debris that may hinder the proper functioning of the propulsion system when loaded with a new capsule and re-used. The tube packaging also enables the pressure retaining mechanism to be integrally mounted to the capsule, and disposed of with the capsule. A user thus only needs to unscrew the front housing portion 26 and replace the used capsule 3 after use with a new capsule. It will however be apparent to the skilled person that the pressure retaining mechanism may be provided separately from the capsule.

The propulsion system in this embodiment is actuated by pressing a rounded or otherwise somewhat pointed trigger head 48 against the tube, thereby generating high transverse local stress to rupture the tube. The trigger head projects through a lateral opening in the housing and is mounted on a flexible or rotatable lever arm 50 fixed to the housing. The skilled person will appreciate that there are many ways of mounting and displacing the trigger head without departing from the spirit of this invention.

The overall length of the pressure retaining tube is preferably greater than the travel of the capsule piston 30 so as to leave some space between the shoulders 40, 46 of the propulsion system housing and the piston 10 respectively, after completion of injection.

For all embodiments described herein, the propulsion system forms a separate unit that can be assembled, at its front end, to different capsules or mechanisms to be driven by the pressure transmitting piston. The propulsion system or unit according to this invention may thus be used not only for needle-free injection devices, but for a range of other applications such as emergency braking systems, cable cutters or crimpers, piezo-electric charge generators, piercing tools, and tools for shooting projectiles. For example, a cable sectioning mechanism 54, for cutting a cable 55, comprising a cutting tool 56 mounted in a housing portion 26' for assembly to a front end of the propulsion unit, may be provided in replacement of the housing portion 26 and capsule 4 of the injection device. By replacing the cutting edge of the cutting tool with a larger bearing surface, a cable clamp, crimping unit or brake may be made. Another example is a electric discharge unit 60 based on the compression of piezo-electric elements 62 in a dielectric housing portion 26" mountable to the propulsion unit in lieu of the housing portion 26 and capsule 4.

As concerns the propulsion of a liquid, a plurality of nozzle orifices may be provided, for example to increase spatial distribution of the liquid to be propelled. In liquid injection delivery systems this may be advantageous to reduce initial local concentration of the liquid in tissue.

Referring to figures 2a to 2d, a single-use disposable propulsion system is shown comprising a container 208, a pressure transmitting interface member in the form of a piston 210, 230, a pressure retaining mechanism 212, an actuation mechnanism 213, and a primary source of potential energy 216 for propelling the pressure transmitting member. The skilled person will appreciate that the propulsion system may comprise multiple sources of potential energy as discussed above in relation to the embodiment of figures 1a and 1b. In this embodiment there is no re-usable pressure generating mechanism since the system is for single-use. The energy sources will in many applications be put under pressure in the container 208 during manufacturing of the propulsion

system. It is however conceivable that the energy source or sources be compressed by the user, for example by crushing and thereby permanently deforming the container wall with a crimping or crushing tool.

A capsule 204 containing the liquid to be injected is mounted at a front end of the propulsion system and held in the container, for example by an inwardly crimped collar portion 217. The capsule comprises a nozzle portion 237 and a flexible membrane 239 encapsulating the liquid 6. The capsule may also be provided with a similar design to the capsule described in relation to figures 1a and 1b. As discussed above, the propulsion unit may also be assembled to various devices or tools in lieu of the capsule for use in other applications.

The pressure retaining mechanism 212 is mounted in compression between a shoulder 247 of the movable pressure transmitting member 210 and an abutment shoulder 240 of an insert 247 held by indents 241 in the container. The pressure retaining mechanism 212 comprises a brittle breakable tubular element 242 similar in features and function to the pressure retaining mechanism described in relation to figures 1a and 1b. The propulsion system in this embodiment is actuated by pressing a spherical ball 248, which acts as a trigger head, against the tube 242, thereby generating high transverse local stress to rupture the tube. The ball projects through a lateral opening 249 in the housing and is pressed inwards by squeezing together a pair of tongues 251 of a collar 250 mounted around the propulsion system container. A removable stop 253, which prevents actuation of the device, is positioned between the collar tongues 251 and is also fixed to a cap portion 255 covering the nozzle orifice until removed.

Referring to figures 3a to 3c, a single-use disposable propulsion system is shown comprising a container 308, a pressure transmitting interface member in the form of a piston 310, a pressure retaining mechanism 312, an actuation mechnanism 313, and a primary source of potential energy 316 for propelling

the pressure transmitting mechanism. The skilled person will appreciate that the propulsion system of this embodiment may further comprise multiple sources of potential energy as discussed above in relation to the other embodiments. As further discussed above, the propulsion unit may be assembled to a capsule 304 containing a liquid to be propelled, or to various devices or tools in lieu of the capsule for use in other applications.

The embodiment of figures 3a to 3c differs from the embodiment of figures 2a to 2d primarily in the following: the pressure retaining mechanism is mounted at a rear end of the system; the actuation mechanism 313 ruptures the pressure retaining mechanism with an inertial shock; and a dosage adjustment mechanism 360 is provided. The dosage adjustment mechanism 360 is movably mounted on the propulsion system housing 308, in this example by engagement of complementary threaded portions 362, 363 on the housing 308 and dosage adjustment mechanism 360 respectively. Axial displacement of the dosage adjustment mechanism 360 adjusts the travel *L* of the piston 310, thus varying the volume of liquid propelled out of the capsule 304. A stop member 364 fixed to, or integrally formed with the pressure transmitting mechanism 310, provides an abutment shoulder 366 that abuts against a complementary shoulder 369, for example a rear facing end, of the dosage adjustment ring 360. The dosage adjustment ring may be manually displaced by a user turning the ring, whereby markings on the propulsion system housing or other indicator means displaying the axial position of the adjustment ring relative to the housing, allow the user to accurately set the dosage.

The pressure transmitting member 310 comprises an application end piston portion 370 fixed to a rod portion 72 which extends to a rear end of the propulsion unit, and the stop member or portion 364 also fixed to the rod portion. The pressure retaining member 312, which may comprise a tubular element similar to those described above in relation to the embodiments of figures 1a -1b and 2a-2d, is under compression between the shoulder 366 of

the stop portion 364 and a retaining shoulder of the propulsion system housing 308. The actuation mechanism 313 comprises an inertial trigger 374 engaged by a spring 376 that exerts a force on the trigger head to drive it towards the retaining element 312. The spring is held in a pre-stressed condition prior to actuation as shown in figure 3a, in this example by engagement of the trigger head against a shoulder 378 provided on the rod portion 372 when in a prestressed loaded position as shown in figure 3a. The rod portion extends through a central opening in the trigger head, the central opening being large enough to allow the trigger head to slide towards the retaining tube 312. In the loaded position, the rod portion is bent out of its neutral or non stressed position by a locating element 380 mounted to the rod portion at a rear end thereof and located in a movable guide member 382. The locating element and movable guide member may take on many forms. In this embodiment the locating member comprises a spacer flange portion 383 having an off-centre locating hole 384 through which the rod portion is inserted.

To actuate the propulsion system, a user takes off the protective cap 355 mounted over the nozzle portion 337, grips the guide member 382 and slidably moves it towards the application end 334 of the system until it disengages the locating element 380. This axial sliding action is advantageous in injection systems since it corresponds to the natural movement when a user applies the injection device against his or her skin while gripping the rear end of the device, and reduces the risk of a lateral displacement of the nozzle portion during injection. The guide member may be held in the pre-actuated or loaded position as shown in figure 3a by spring means. In the example shown, the guide member is in the form of an elastic or deformable tubular sheath 385, for example of a plastic material, extending over a substantial portion of the length of the propulsion unit. The sheath may for example be fixed to the propulsion unit housing near the application end and comprise a deformable or collapsible portion 386 that allows axial displacement of the rear end of the sheath during actuation. It may be noted that in this embodiment, the sheath is provided with

an opening 388 at the level of the dosage adjustment ring 360 to allow access thereto.

The rod portion thus freed, biases to its neutral position such that the trigger head disengages the rod portion shoulder 378 and accelerates towards the retention mechanism under the force exerted by the spring element 376, as best seen in figure 3b. When the spring has fully collapsed, as shown in figure 3c, or the trigger head hits a portion of the pressure transmitting means, an inertial shock impulse is generated that shatters or otherwise ruptures the brittle pressure retaining member 312, thereby releasing the pressure transmitting piston 310.

The rupture of the retaining member by inertial shock, may also be performed by a trigger head projected laterally, for example a trigger head similar to the ones described in relation to the embodiments of figures 1 and 2 that is elastically projected or otherwise driven with a certain velocity against the retention tube in a substantially radial direction.

Claims

1. A propulsion system comprising a housing, a movable pressure transmitting member adapted to apply a force on a device or matter to be propelled by the propulsion system, a source of potential energy in the housing applying pressure on the pressure transmitting member, a pressure retention mechanism for retaining the pressure transmitting member relative to the housing prior to actuation, and an actuation mechanism for liberating the pressure transmitting member, characterised in that the pressure retention mechanism comprises a retaining element mounted in compression between the pressure transmitting member and the housing, the retaining element adapted to be broken by the actuation mechanism in order to release the pressure transmitting member.

2. Propulsion system according to claim 1, wherein the retaining element comprises a thin-walled tubular portion

3. Propulsion system according to claim 2 wherein the tubular portion comprises a substantially cylindrical shape.

4. Propulsion system according to claim 2 or 3 wherein the tubular portion comprises radially inwardly or outwardly curved axial ends, or a slight barrel shaped portion, to impart a certain bending moment in the tubular portion under compression.

5. Propulsion system according to claim 2, 3, or 4, wherein the tubular portion is made of a brittle material, such as a ceramic or a hardened steel.

6. Propulsion system according to any one of claims 2 to 5 wherein the tubular portion is manufactured from extruded or rolled sheet metal.

7. Propulsion system according to any one of the preceding claims wherein the retaining element is encapsulated in a packaging material.

8. Propulsion system according to any one of the preceding claims wherein the actuation mechanism comprises an inertial trigger adapted to rupture the retaining element with an inertial shock.

9. Propulsion system according to any one of the preceding claims wherein the actuation mechanism comprises a trigger head for generating a stress on the retaining element in a direction transverse to the axial compression direction.

10. Propulsion system according to claim 8 wherein the actuation mechanism (313) comprises an inertial trigger head (374) engaged by a spring (376) that exerts a force on the trigger head to drive it towards the retaining element (312).

11. Propulsion system according to the preceding claim wherein the trigger head engages a shoulder (378) provided on a rod portion (372) of the pressure transmitting member when in a prestressed loaded position.

12. Propulsion system according to the preceding claim wherein the rod portion extends through a central opening in the trigger head, the central opening being large enough to allow the trigger head to slide towards the retaining element (312).

13. Propulsion system according to the preceding claim wherein, in the loaded position, the rod portion is bent out of its neutral or non stressed position by a locating element (380) mounted to the rod portion and received in a movable guide member (382).

14. Propulsion system according to the preceding claim wherein the guide member comprises an axially movable sheath portion.

15. Propulsion system according to claim 9 wherein the trigger head comprises a rounded or somewhat pointed surface adapted to generate a high local stress when applied against the retaining element.

16. Propulsion system according to any one of the preceding claims wherein the pressure retaining mechanism is integrally mounted to a disposable device or single-use capsule for assembly in the propulsion system.

17. Propulsion system according to any one of the preceding claims, wherein the energy source comprises a liquid or solid compressible substance, as defined at ambient temperature and pressure, compressed in the housing.

18. Propulsion system according to the preceding claim, wherein the compressible substance belongs to the family of polysiloxanes.

19. Propulsion system according to any one of the preceding claims, wherein the propulsion system comprises a secondary source of potential energy generating a lower pressure than the primary source of potential energy during use.

20. Propulsion system according to any one of the preceding claims, wherein the system comprises an adjustment member (360) for adjusting the travel of the pressure transmitting member during actuation, the adjustment member being movably mounted on the housing and comprising an abutment shoulder (368) for engagement with the pressure transmitting member.

21. Propulsion system according to the preceding claim wherein the adjustment member is in the form of a ring comprising a threaded portion engaging a complementary threaded portion of the housing.

22. Liquid propulsion device comprising a propulsion system according to any one of the preceding claims, further comprising an ampoule or capsule containing the liquid to be propulsed and a nozzle portion having at least one nozzle orifice, mounted or assembled to the propulsion system.

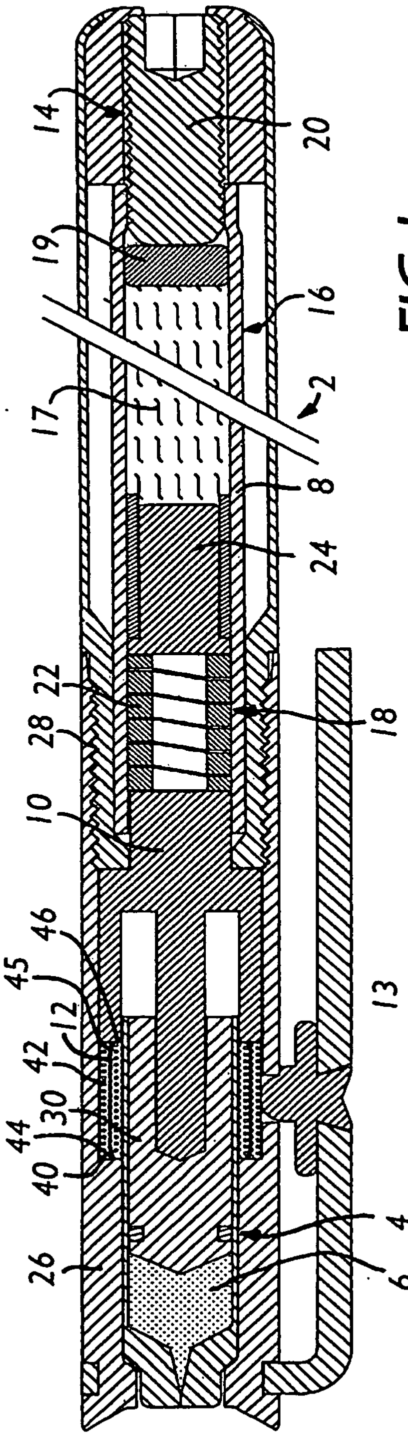
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FIG. 1 a

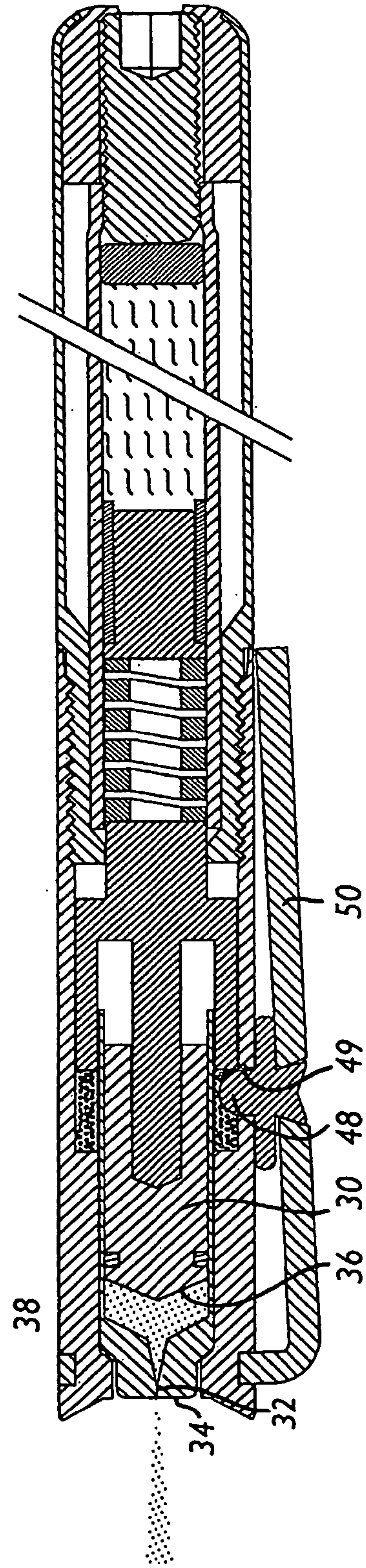
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FIG. 1 b

FIG. 1c

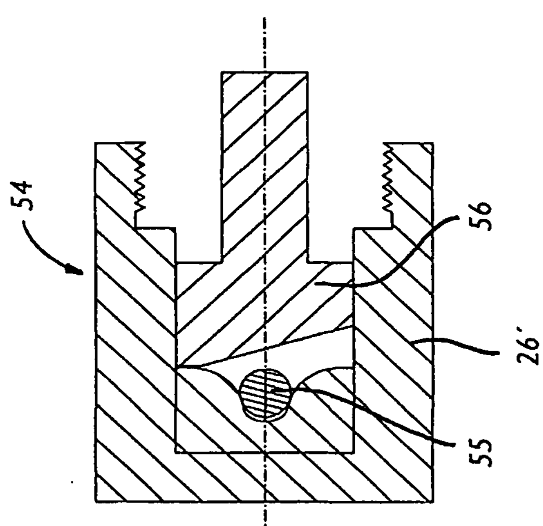
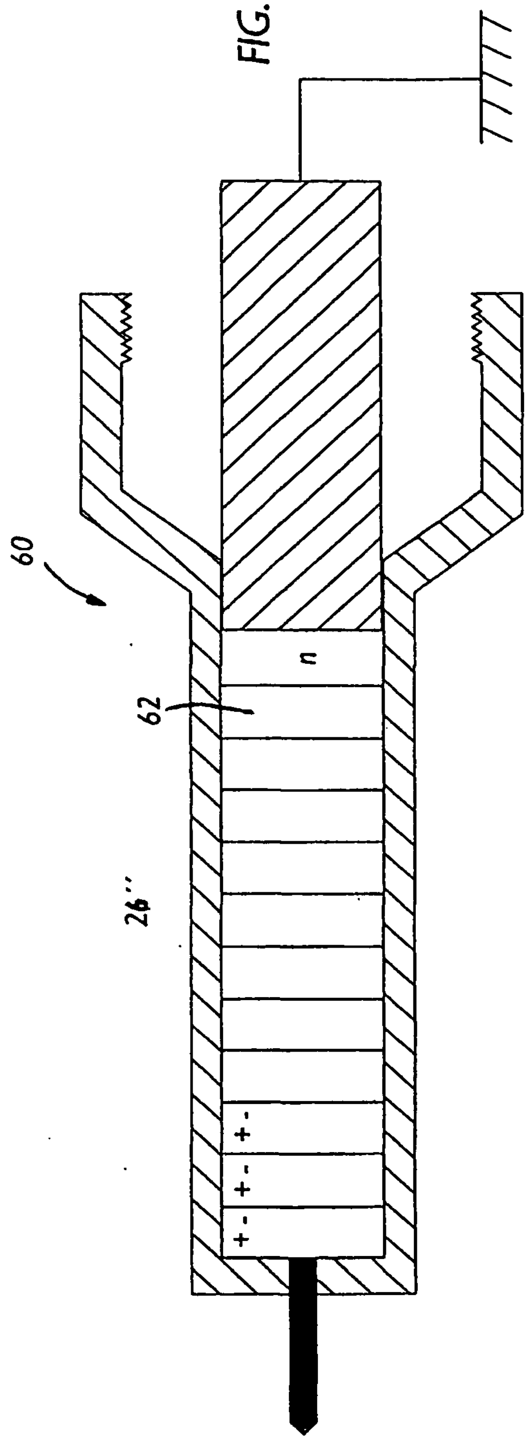
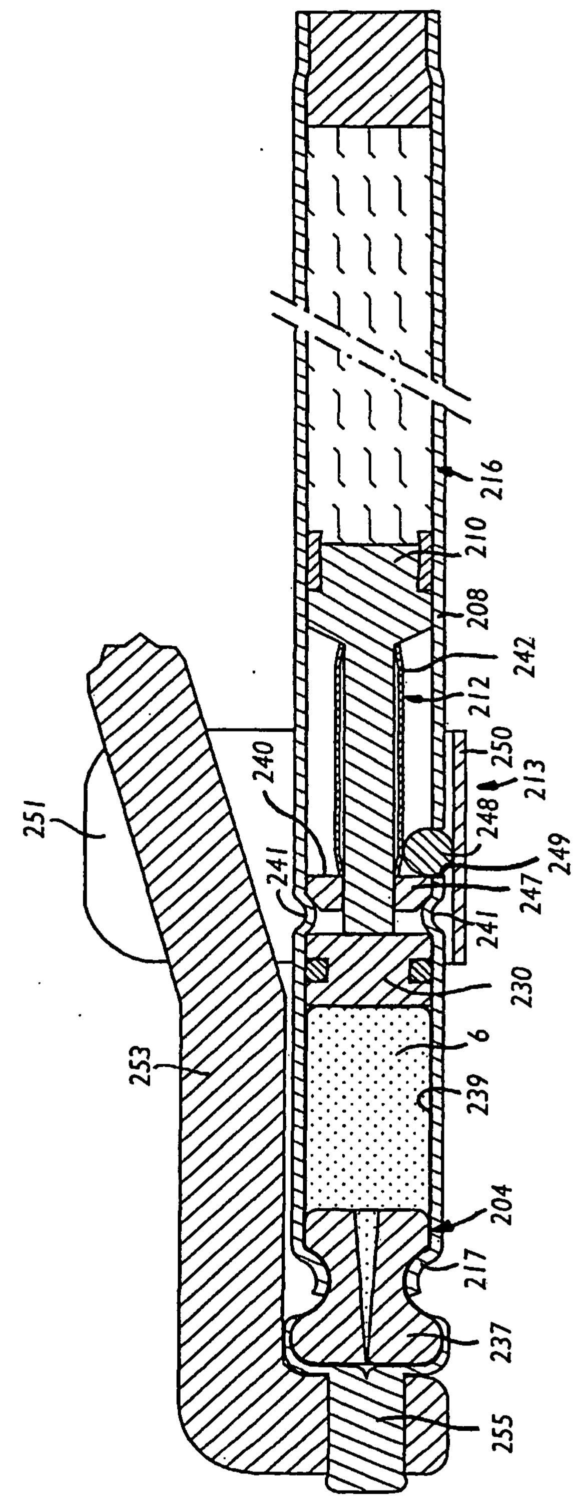


FIG. 1d




216
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250
213
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251
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241
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6
253
239
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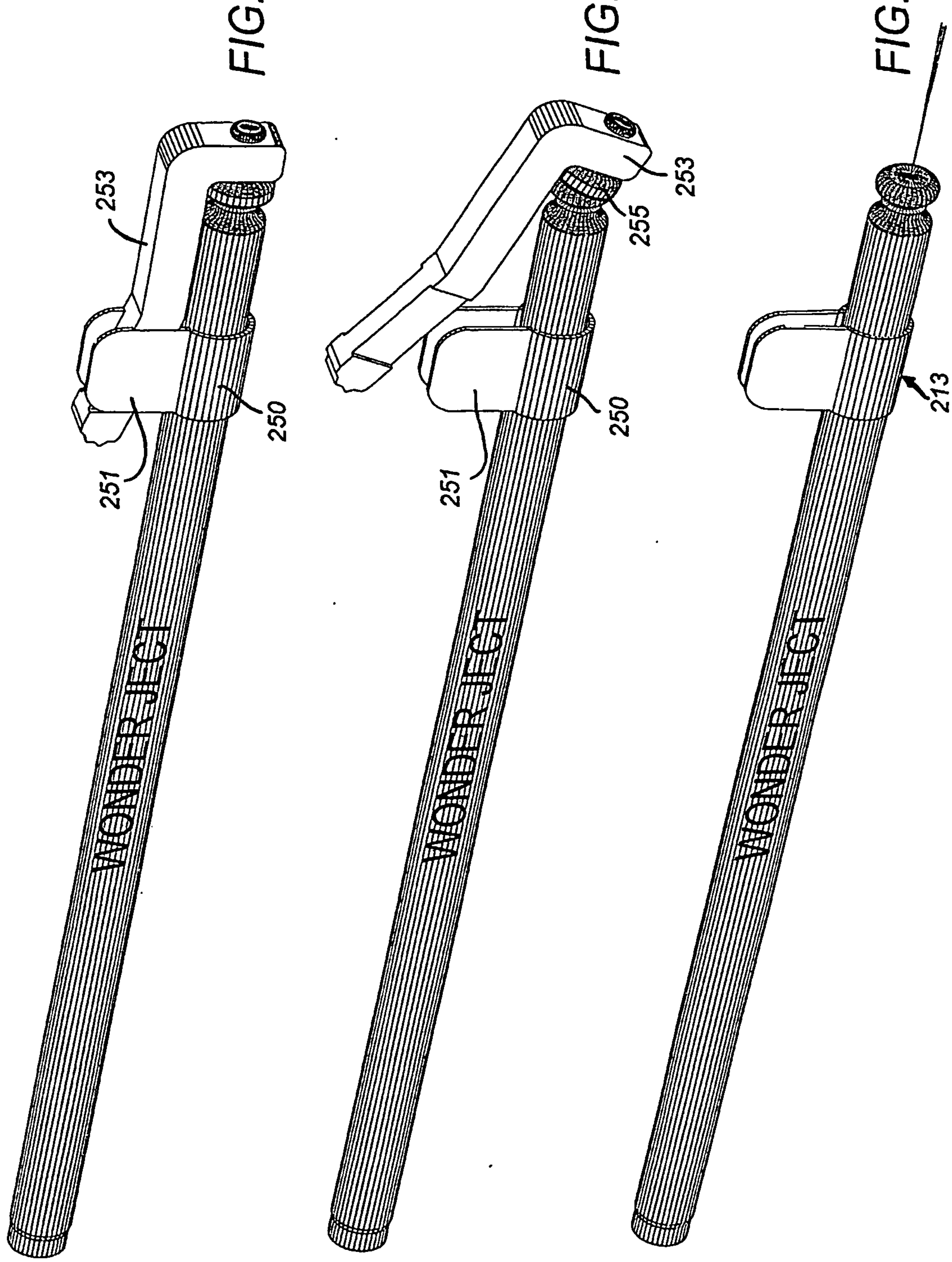
217
237
255

FIG.2 a

FIG.2 b

FIG.2 c

FIG.2 d



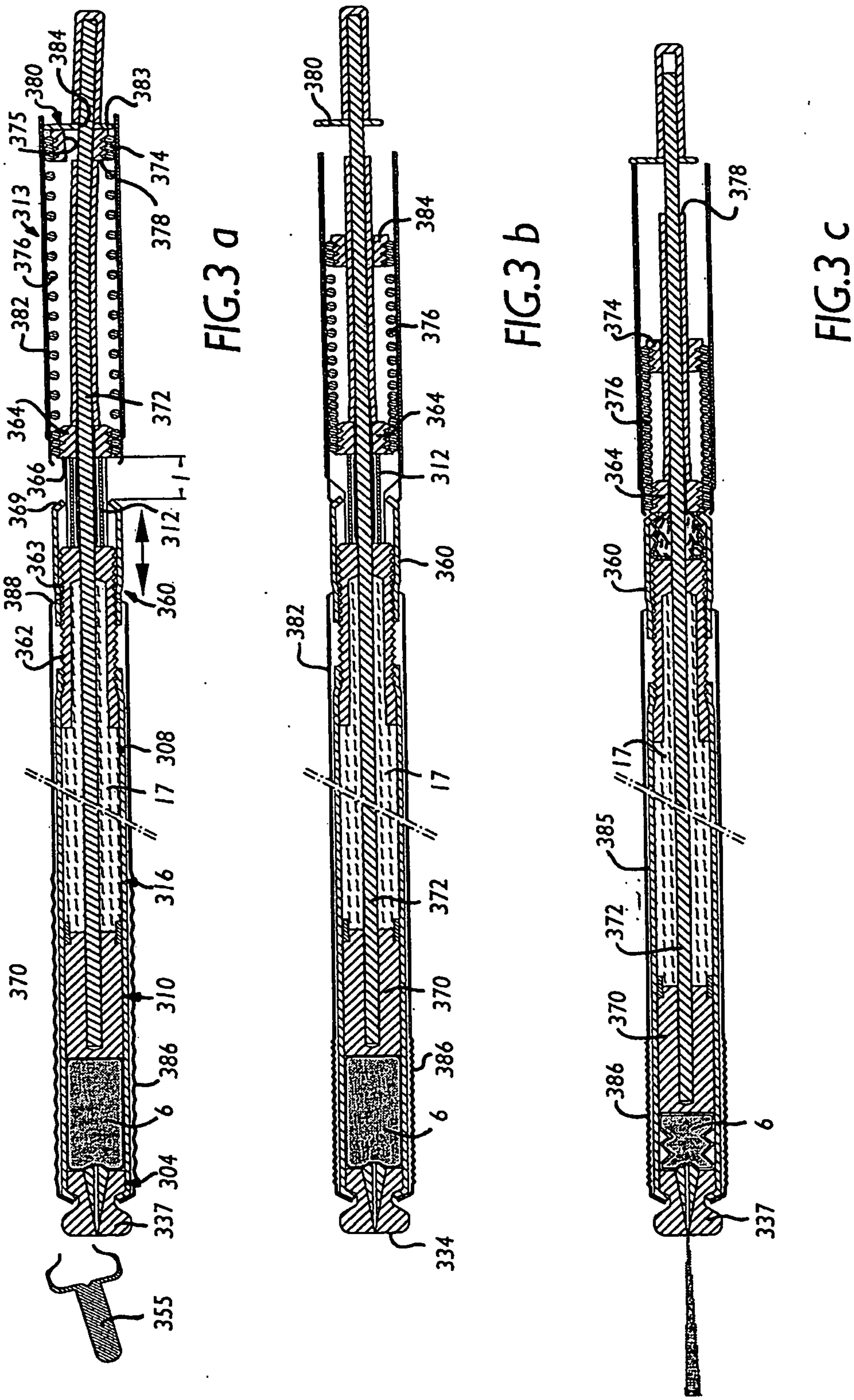
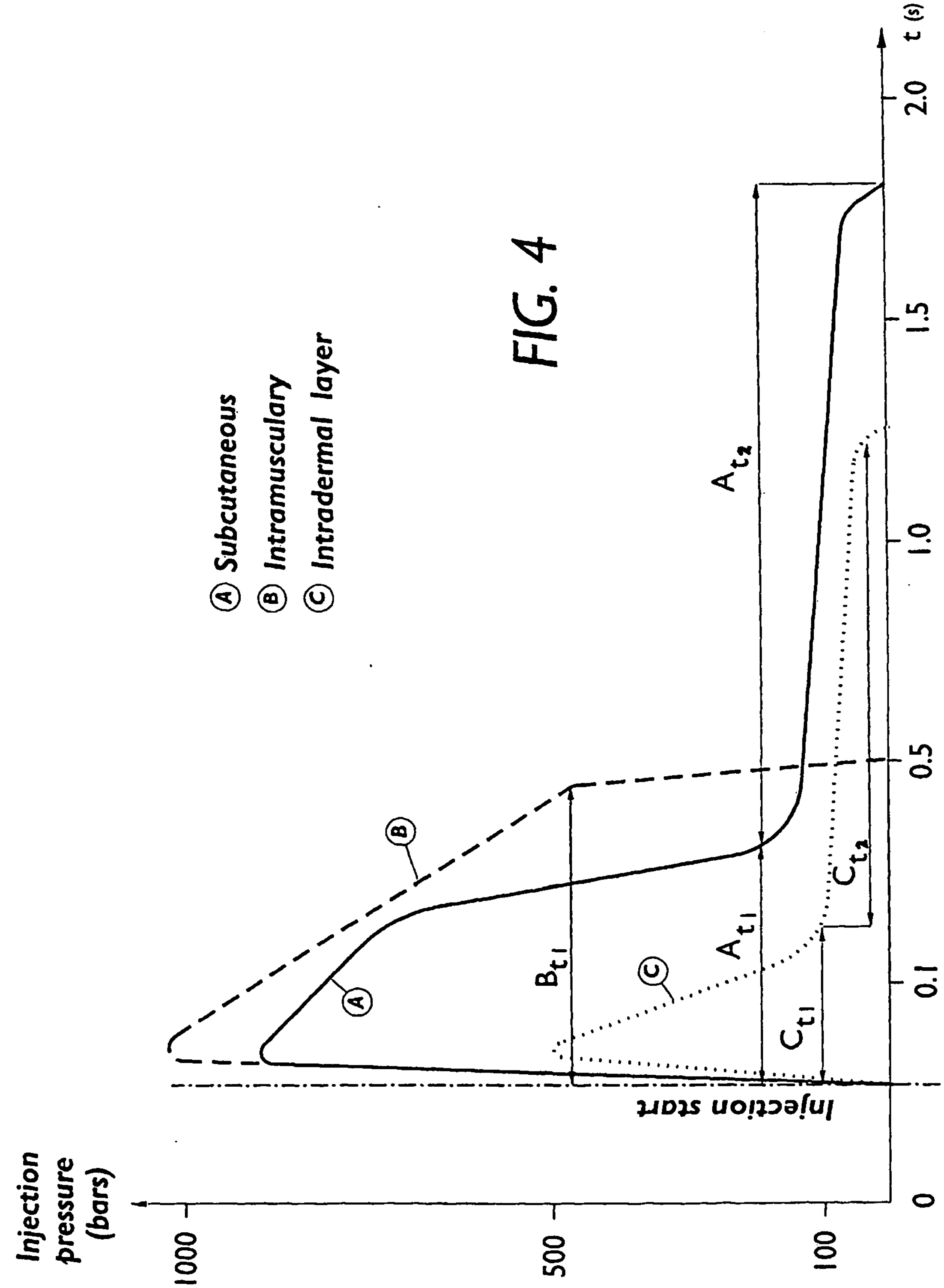


FIG.3 a

FIG.3 b

FIG.3 c



Injection pressure (bars)
1000
500
100
0
t = 0
0.1
0.5
1.0
1.5
2.0
t (s)
Injection start
A Subcutaneous
B Intramuscular
C Intradermal layer
A
B
C
B_{t1}
A_{t1}
C_{t1}
A_{t2}
C_{t2}

FIG. 4

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB 03/00247

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61M5/48 A61M5/20 A61M5/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 913 699 A (PARSONS JAMES S) 3 April 1990 (1990-04-03) abstract column 4, line 58 -column 5, line 9; figures 1-4	1
A	EP 1 033 143 A (HOFFMANN LA ROCHE) 6 September 2000 (2000-09-06) paragraphs '0033!,'0034!; figures 7-10	1
A	WO 01 47586 A (NERACHER ARNOLD) 5 July 2001 (2001-07-05) cited in the application abstract; figures 1,2,34	1

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means
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Date of the actual completion of the international search	Date of mailing of the international search report
24 June 2003	02/07/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Nielsen, M

INTERNATIONAL SEARCH REPORT

Internat   l Application No
PCT/IB 03/00247

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	WO 00 10630 A (GIBBINS GRAHAM ROGER ;NUSSEY MATTHEW SIMON (GB); WESTON MEDICAL LT) 2 March 2000 (2000-03-02) abstract page 4, last paragraph -page 5, paragraph 2; figure 1	1
A	GB 2 173 237 A (TAYLOR HARRY) 8 October 1986 (1986-10-08) abstract; figures 1,2	1

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